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LONGMONT WASTEWATER TREATMENT FACILITY, LONGMONT, COLORADO

ENVIRONMENTAL PROTECTION AGENCY

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The purpose of the report is to summarize the results and findings of the technical assistance project that was conducted at the Longmont, Colorado, waste water treatment facility.

The initial objective to improve the plant's operations and the effluent quality was successful to a degree and is documented in this report.

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TECHNICAL ASSISTANCE PROJECT

LONGMONT WASTEWATER TREATMENT FACILITY

LONGMONT, COLORADO

March - May 1972

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I. INTRODUCTION

Region VIII of the United States Environmental Protection Agency developed an Accomplishment Plan for the Metropolitan Denver-South Platte River Basin areas. A portion of this plan called for an evaluation of the waste water treatment facilities in the Metropolitan Denver area regarding their operational and maintenance practices. (Initially only five plants were selected for visits.) One of the purposes of the plant evaluations was to determine those facilities where regional resources could be used to improve existing effluent quality by improving operational controls.

The waste water treatment facility at Longmont, Colorado, was one of the plants evaluated. The Longmont plant was producing a poor quality effluent (in violation of Colorado's Water Quality Standards, i.e., 80 percent removal of BOD_5) and it was concluded to be a candidate for technical assistance. An assistance project aimed at improving the plant's operations and upgrading effluent quality was begun on March 20, 1972. Simultaneously a project to provide assistance in conducting laboratory analyses was started.

II. PURPOSE AND SCOPE

The purpose of this report is to summarize the results and findings of the technical assistance project that was conducted at the Longmont, Colorado, waste water treatment facility.

The initial objective to improve the plant's operations and the effluent quality was successful to a degree and is documented in this report. In addition, those portions of the plant that apparently limited further improvement of effluent quality are discussed. The laboratory assistance is outlined and some of the problems encountered are also discussed.

III. DESCRIPTION OF PLANT

A. Background

The Longmont Wastewater Treatment Facility was recently expanded (1971). Prior to plant expansion, the city had been provided secondary treatment by a rock media trickling filter. The new plant expansion initially called for replacement of the existing rock media with redwood slats and, in addition, the construction of a new redwood media filter (the Del-Pak Media Corporation provided the redwood slat media at Longmont). Actually, only the new redwood media filter was constructed since it was decided to determine if the redwood and the associated process designated as the Activated Biofilter (ABF)* could handle the high BOD_5 loading rates used in design of the redwood filters. Redwood was purchased to replace the rock media in the old filter but the slats have not been installed to date.

* ABF and Activated Biofilter are trademarks of Del-Pak Corporation.

The plant has continually experienced problems in meeting the State's minimum requirement of 80 percent reduction of BOD_5. A local turkey processing plant which is in operation for most of the year (May to January or February) has, in the past, increased the load of BOD_5 to the Longmont plant considerably. At these higher loadings the plant has been able to achieve the minimum 80 percent reduction of BOD_5. However, the effluent discharged to the river at these higher loading rates is of poor quality.

B. Plant Facilities

Figure 1 shows the basic flow diagram for the Longmont plant as outlined in the operator's manual provided by the consulting engineer. A brief discussion of the various units will be outlined below.

Flow entering the plant passes through a mechanical bar screen and is then split into two separate streams. By design, fifty-seven percent of the flow is diverted to the "old" rock filter side of the plant and forty-three percent goes to the new ABF filter side, however, these percentages can be adjusted by changing gates.

The flow to the rock filter side of the plant passes through a primary clarifier and into a wet well. The sewage is pumped to the rock filter and the effluent from the filter is partially returned to the wet well to be recirculated while the remainder of the flow is settled in the final clarifier. Settled sludge from the secondary clarifier is pumped back to the head of the plant to be settled out in the primary clarifiers.

The sewage to the ABF side of the plant passes through a primary clarifier and then into a wet well. Sewage is then pumped to the ABF filter (tower). A portion of the "mixed liquor" from the bottom of the ABF tower is returned to the wet well to be recirculated with the incoming sewage. The remainder of the flow is settled in the final clarifier. Settled solids from the final clarifier (return sludge) are also returned to the wet well to be recirculated over the tower with the incoming sewage. A portion of these settled solids are "wasted" each day back to the head of the plant where they are removed in the primary clarifier.

Disinfection at Longmont is accomplished by chlorination. A portion of the final clarifier is used to provide contact time for the chlorine. No chlorine contact tank is available.

Sludge from the primary clarifiers is pumped at a low solids concentration through a cyclone type grit separator and then flows to a sludge thickener. Sludge from the thickener is pumped to the digestor or at times it has been centrifuged and the centrate returned to the sludge thickener. Centrifuged sludge is hauled to a land fill. The overflow from the sludge thickener is returned to the head of the plant.

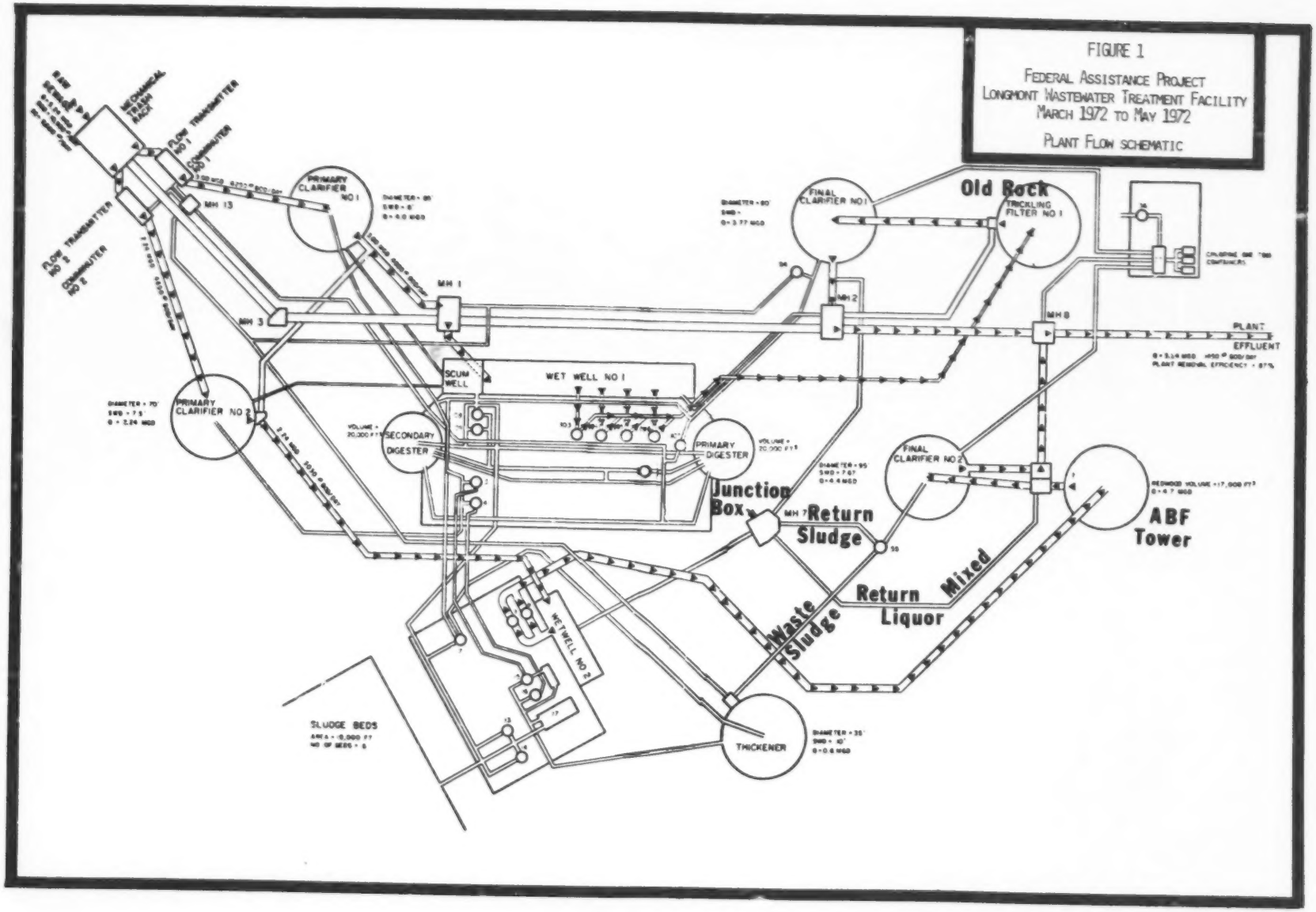
FIGURE 1
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
PLANT FLOW SCHEMATIC
MECHANICAL TRASH RACK
FLOW TRANSMITTER NO 1
COMPUTER NO 1
FLOW TRANSMITTER NO 2
COMPUTER NO 2
PRIMARY CLARIFIER NO 1
PRIMARY CLARIFIER NO 2
MH 1
MH 2
MH 3
MH 8
MH 13
SCUM WELL
WET WELL NO 1
WETWELL NO 2
SECONDARY DIGESTER
PRIMARY DIGESTER
FINAL CLARIFIER NO 1
FINAL CLARIFIER NO 2
Old Rock
TRICKLING FILTER NO 1
PLANT EFFLUENT
Junction Box
MH 7
Return Sludge
Waste Sludge
Return Mixed Liquor
ABF Tower
SLUDGE BEDS
THICKENER

Sludge pumped to the digestor is treated in the gas recirculation primary digestor and is then drawn to the secondary digestor. Under normal operation, the supernatant from the secondary digestor is returned to the head of the plant and the sludge is either drawn to drying beds or centrifuged. Presently no flocculating agents are used during the centrifuging of digested sludge.

Unit sizes and some design criteria are shown on Figure 1. It is noted that very little interconnection exists between the two sides of the plant. Figure 1 shows the interconnection available at Manhole #7 (Junction Box). At this point, effluent from the rock filter could be introduced to the ABF side of the plant. This junction box is also the location where the return sludge and return mixed liquor from the ABF filter are mixed before they are returned to the wet well for recirculation.

The return mixed liquor line (labeled on Figure 1) is a 10" unvalued line through which the mixed liquor flows by gravity to the junction box.

IV. SUMMARY OF PROJECT

A. Summary of Laboratory Assistance

1. Review of Laboratory Procedures

At the time of the laboratory assistance program the plant chemist was analyzing eight composited samples each day. These samples were composites of seven grab samples of uniform volume collected every two hours over a period of fourteen hours (0800 hrs to 2200 hrs). Samples were not composited in relation to the incoming flow. One of the composite samples was raw influent waste water collected upstream from the bar screen. The next four composite samples were collected from each of the two primary clarifier effluents and each of the two filter effluents (rock filter and ABF tower). The last three samples were collected from each of the two final clarifier effluents and the combined final effluent. These effluents had been chlorinated. The final effluent sample was collected at a junction box where the flows from each of the two filters came together. Although every effort was made to collect a representative sample, it is possible that this final effluent sample was not a well mixed representative sample.

The analyses performed on these samples consisted of: BOD_5, total solids, total volatile solids, total suspended solids and pH. Also, residual chlorine was determined on the two final clarifiers and final effluent samples at least once a day. Dissolved oxygen concentrations were determined in the effluents from the ABF and rock filters once each day.

Generally, every other day a grab sample was collected from each of the anaerobic digestors. These samples were analyzed for volatile acids, alkalinity concentration and pH.

The technique used to set up the individual dilutions for the five day Biochemical Oxygen Demand analysis was a simplified cylinder dilution technique. The initial and five day dissolved oxygen concentration was determined by the Azide Modification of the Dissolved Oxygen Method listed in Standard Methods for the Examination of Water and Wastewater, 13th Ed.

The sodium thiosulfate titrating solution used in the determination of the dissolved oxygen was prepared properly, when needed. However, this unstable solution was not properly preserved. As a result, the concentration of the solution gradually decreased. Therefore the accuracy of each day's titration values were a function of the freshness of the sodium-thiosulfate solution.

An important change initiated during the laboratory assistance program was the institution of the policy of preserving the sodium thiosulfate solution with chloroform and periodically checking the concentration using standard potassium biniodate solution. In addition, the full bottle technique of the Azide Modification of the Dissolved Oxygen Method was introduced to the chemist; i. e. the entire volume of solution in the BOD bottle (305 ml) is titrated with 0.0375N sodium thiosulfate solution and therefore the relationship of one ml of titrating solution to one mg/l of dissolved oxygen remains the same.

A few days after this technique was taught to the chemist, the City of Longmont decided to purchase a dissolved oxygen meter and probe. The chemist, as well as other plant personnel, was instructed in the proper calibration and operation of the dissolved oxygen meter and probe for determining BOD_5.

Other changes initiated consisted of using a large fish tank aerator pump and a stone (fine bubble) diffusor to aerate the dilution water at 20°C. Also a siphon was used to transfer the diluted sample from the graduated cylinders to the BOD bottles with a minimum amount of agitation. Samples were previously poured from the graduated cylinders. Wide tipped serological pipets were purchased to aid in the accurate measurement of waste water samples for both BOD and suspended solids analytical procedures.

Dissolved oxygen concentration of waste water samples were determined by a modification of the Copper Sulfate-Sulfamic Acid Flocculation Modification for the determination of dissolved oxygen. This procedure was modified and the operator was instructed in the proper calibration and operation of the dissolved oxygen meter and field probe. The measurement of dissolved oxygen using the meter and probe became part of the control testing program performed by the plant operators.

Chlorine residual was determined on grab samples collected from both final clarifiers and the final effluent by the orthotoledine method. No change was suggested in this method.

Prior to assistance no attempt was made to remove the residual chlorine from the composited sample before setting up the BOD sample bottles. This procedure was modified by instructing the chemist in the proper pretreatment procedure to remove the effects of residual chlorine on samples.

The plant chemist was performing total suspend solids on the composited samples by filtering a constant volume (50 ml) of sample through a gooch crucible containing a Whatman ashless filter paper. This method produced reasonably good results; however, the use of the paper filter prevented the determination of volatile suspended solids. To enable the chemist to determine VSS, Reeves Angel 934AH glass fiber filters were substituted. Also, to increase precision, the volume of sample filtered was varied inversely with the suspended solids concentration.

Total solids and total volatile solids were determined by satisfactory micro-methods, therefore no change in this procedure was suggested.

2. Accomplishments

BOD data was improved from unreliable and extremely variable to precise and reliable analytical results. This improvement was achieved by changes in laboratory technique such as the preservation of the sodium thiosulfate solution and the removal of the residual chlorine from the chlorinated samples. The change from variable to consistent effluent BOD_5 values is shown on Figure 9. Prior to March 22 (the first day of improved BOD_5 results) the effluent BOD_5 values were extremely variable. On March 16th, the BOD_5 was 98 mg/l, on the 17th it was 22 mg/l and back up to 87 mg/l the 18th. After March 23rd, most of the effluent BOD_5 results were in the 30 to 70 mg/l range.

Minor changes in equipment and techniques were made in the analysis of solids. These changes increased laboratory efficiency but didn't significantly change the results.

From an overall point of view, this laboratory is well equipped and the plant chemist has been instructed in proper laboratory techniques and procedures.

A problem that remains unsolved is the location of the laboratory next to the centrifuge equipment. When the centrifuge is in operation, the vibration transmitted to the laboratory affects the use of the analytical balance. A large granite stone balance table would partially solve this problem.

B. Summary of Operational Assistance

1. Control Testing

In addition to laboratory assistance, plant personnel were also given instruction in conducting and interpreting various control tests. Testing

to aid in the operation of the ABF tower was emphasized since it represented the unit of the plant that was most amenable to control. Dissolved oxygen tests, centrifuge tests, turbidity, settleability tests, and sludge blanket depth in the final clarifiers were the control tests that were initiated. The tests outlined above were conducted at least twice a day, seven days a week.

Dissolved oxygen (D.O.) tests were used to monitor the availability of dissolved oxygen in the plant. D.O. measurements were taken of the mixed liquor and of the mixture of mixed liquor and return sludge at the junction box. (See Figure 1) A dissolved oxygen meter was used to measure the oxygen concentrations.

Centrifuge testing was used to determine variations in solids concentrations from day to day. Tests were conducted on the mixed liquor, the return sludge and the mixture of the return sludge and mixed liquor in the junction box. The centrifuge tests result in a percent solids determination. Although it is not necessary for control, a correlation between percent solids by centrifuge and solids by weight was made. The results of this correlation indicate that one percent solids from the centrifuge test is equivalent to 1286 mg/l solids by weight. This factor may change as the sludge characteristics change; however, solids concentrations presented by weight in this report have been converted using the above factor.

Turbidity testing was done on the effluents from both the rock filter and the ABF filter to monitor improvements in performance prior to obtaining a BOD_5 test result.

Settleability tests were conducted on the mixed liquor from the ABF tower to monitor and observe settling characteristics.

Sludge blanket depth determinations were made on the final clarifier on the ABF side of the plant to monitor changes in the depth of the blanket and to determine if the sludge was accumulating in the clarifier.

Longmont has recently purchased the equipment to conduct the above outlined control tests and is continuing to use these tests to control their operations.

2. Data Interpretation

The data obtained from the above outlined control tests were used to perform calculations and to develop graphs that were used and are continuing to be used to control the ABF filter.

The dissolved oxygen measurement of the mixed liquor and of the mixture of return sludge and mixed liquor measured at the junction box was plotted versus time. It was found that if the concentration of dissolved oxygen at this junction box fell below 1 mg/l during the day that performance of the

ABF tower, as measured by turbidity, decreased. A daily plot was also made of the mixed liquor solids concentration versus time. It was determined that a solids concentration of 3 percent or greater (approximately 3800 mg/l) in the mixed liquor caused a decrease in the dissolved oxygen at the junction box to less than 1 mg/l. Therefore, optimum performance was achieved by attempting to maintain suspended solids at approximately 3 percent as measured by the centrifuge test. Solids concentrations were maintained at a desired level by selecting and wasting to the primary clarifiers a desired amount of sludge from the ABF system each day. The amount of sludge wasted was plotted daily to show the correlation between sludge wasted and mixed liquor concentration.

Turbidity of the effluent from the ABF unit was plotted daily to depict the quality at various solids concentrations.

The above outlined graphs and calculations are continuing to be developed at Longmont. As plant loadings change and as temperature and other factors change the most desirable operational characteristics will change. The combination of the control tests plus the data analysis should allow the plant operators in the future to recognize the operational changes that are needed.

C. Summary of Plant Performance

1. Analysis of Rock Filter

Prior to the initiation of technical assistance at Longmont, the operator had begun decreasing the flow to the rock filter and increasing flow to the ABF side of the plant. Normally, 57 percent of the flow goes to the rock filter side of the plant. Calculations of loading on the rock filter indicated that prior to flow reduction it was receiving loads in excess of 50 lbs. of BOD_5 per 1000 cubic feet. Calculations also showed that the ABF unit was receiving loads less than design. Therefore, to better distribute the load in the plant, the flow to the rock filter was further decreased during the first week of formal assistance (March 20, 1972). After the first week, an attempt was made to balance the flow equally to each side of the plant. Flow changes are depicted graphically in Figure 2. Seven day moving average flow data is plotted to smooth out the daily fluctuations in flow. The changes in flow indicated after April 9, 1972 were made in an attempt to determine the optimum distribution of flow to get the best effluent quality from the plant. This adjusting of the flow between the two sides of the plant should continue until it is determined that the optimum flow distribution has been achieved.

The effect of the flow reduction on the load to the rock filter is depicted graphically in Figure 3. Daily average values of load as well as the seven day moving average is plotted. Data are not available in sufficient quantity to warrant extension of the curves beyond April 17, 1972. Testing of individual units was discontinued on a daily basis after that date. The load as depicted by the seven day moving average in Figure 3 shows a decrease from approximately

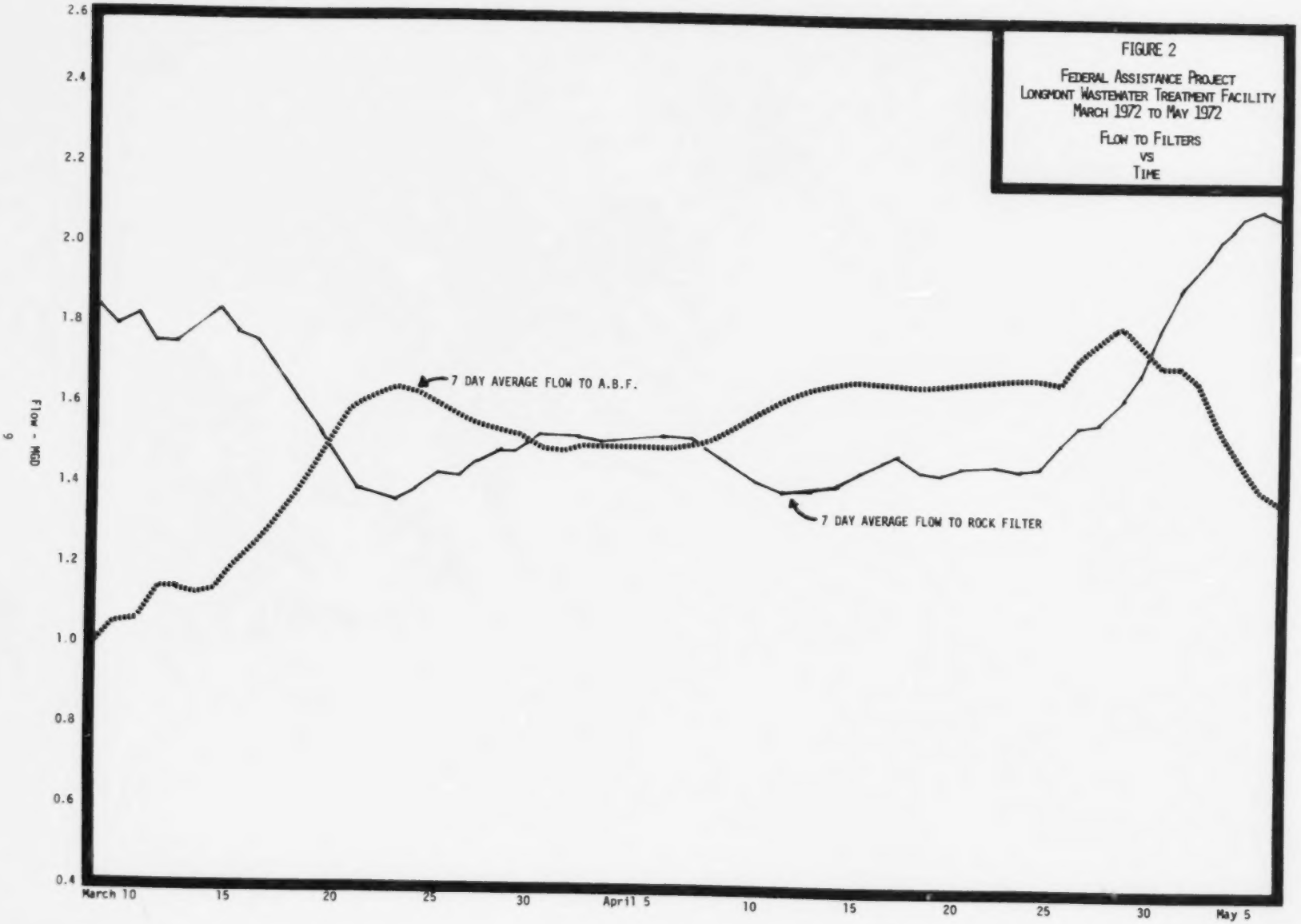
FIGURE 2
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
FLOW TO FILTERS
VS
TIME
Flow - MGD
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
7 DAY AVERAGE FLOW TO A.B.F.
7 DAY AVERAGE FLOW TO ROCK FILTER
March 10
15
20
25
30
April 5
10
15
20
25
30
May 5

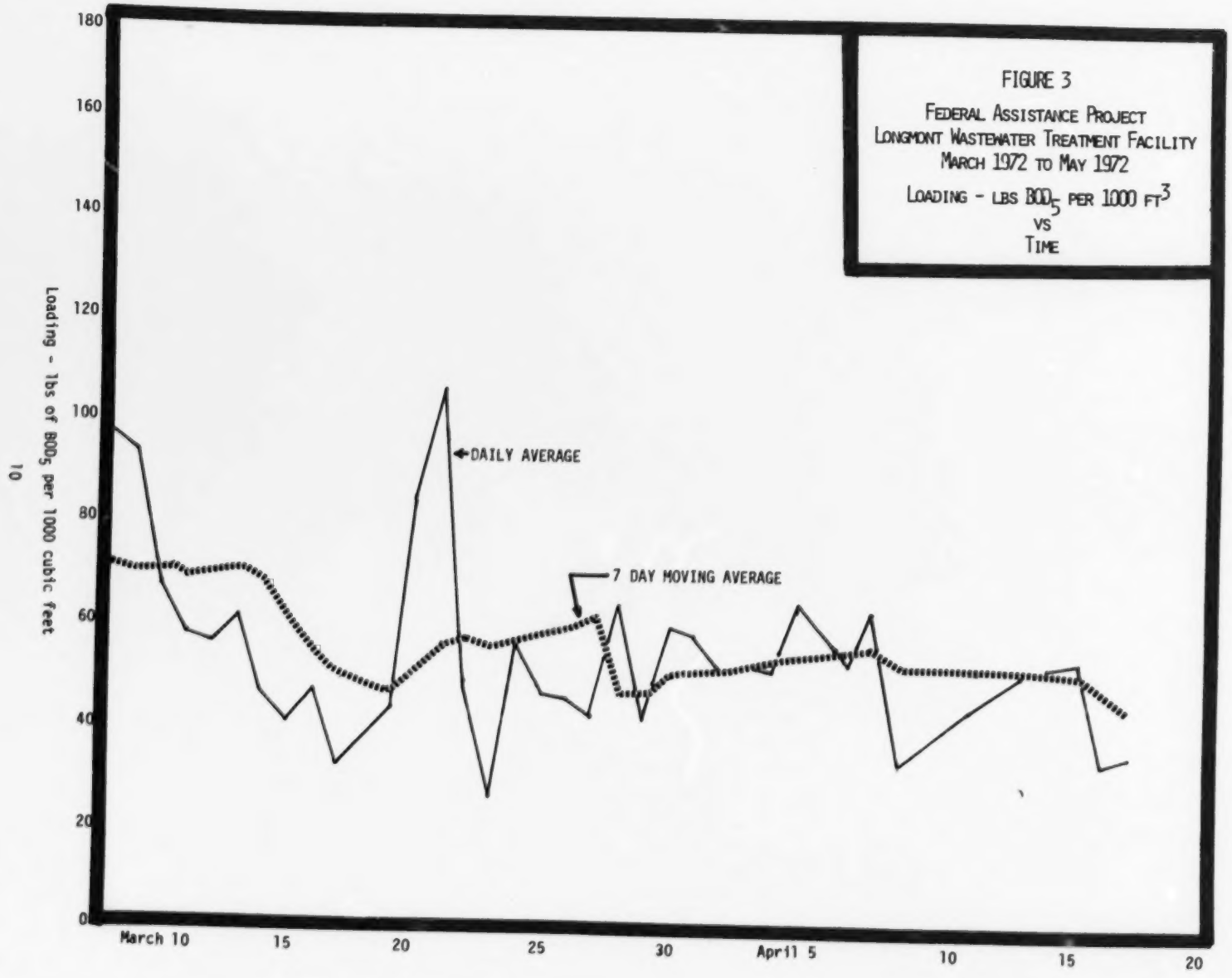
FIGURE 3
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
LOADING - LBS BOD_5 PER 1000 FT^3
VS
TIME
Loading - lbs of BOD_5 per 1000 cubic feet
180
160
140
120
100
80
60
40
20
0
DAILY AVERAGE
7 DAY MOVING AVERAGE
March 10
15
20
25
30
April 5
10
15
20

70 lbs. of BOD_5 per 1000 cubic feet to between 50 to 60 lbs. of BOD_5 per 1000 cubic feet. It is also noted that during this time period air temperatures were generally increasing. The combined result of the increasing temperatures and decreasing load led to an improved effluent quality from the rock filter. Figure 4 depicts the effluent BOD_5 from the rock filter. The seven day moving average indicates a reduction from greater than 70 mg/l BOD_5 to 40 to 45 mg/l of BOD_5. This represents a reduction in the effluent strength of BOD_5 of greater than 35 percent.

Figure 5 shows a plot of the ratio of the effluent BOD_5 to the loading of BOD_5 per 1000 cubic feet versus time. This graph was plotted to show the combined effect that the decreased loading had on the effluent BOD_5 and it shows more dramatically, as indicated by the steeper slope, the improvement of the rock filter.

2. Analysis of ABF Filter

As shown in Figure 2, the flow was increased to the ABF side of the plant. This was possible since during the first week or so of March, the pumps for the ABF wet well were wired so that they could operate simultaneously. This increased the capacity above that which had been available when the pumps could only operate alternately. Another modification that had taken place prior to the formal assistance project was connecting the sludge draw off pump for the secondary clarifier directly to the hopper in the center of the tank. This allowed an increased amount of sludge to be removed from the final clarifier.

During the first week of the assistance project (March 20-27, 1972), the amount of mixed liquor going directly to the wet well was increased to a maximum. This was done by partially closing the gate that allowed flow from the bottom of the ABF tower to enter the clarifier and diverting this flow through the ten inch line available. Closing the gate increased the head in the splitter box and thus allowed the maximum amount of flow to be diverted from the bottom of the tower directly to the wet well. Also, all wasting of sludge (i.e., pumping solids back to the primary clarifiers) was stopped for the week in an effort to increase the solids concentration in the system.

The mixed liquor solids at the start of the project was 0.5 percent (approximately 600 mg/l). During the first week the solids concentration was increased to 2 percent (approximately 2600 mg/l). In the weeks that followed, solids were varied between 2.5 to 4 percent in an effort to determine the concentration that produced the best effluent. It was felt that as the solids increased, one of two things would be the limiting factor. The solids might increase to the point that they would accumulate in the final clarifier and go septic or bulk due to the long detention time, or the other possibility might be a limited concentration of dissolved oxygen would be available as provided by the ABF tower. In practice it was found that the dissolved oxygen became critical long before high solids concentrations became critical in the final clarifier.

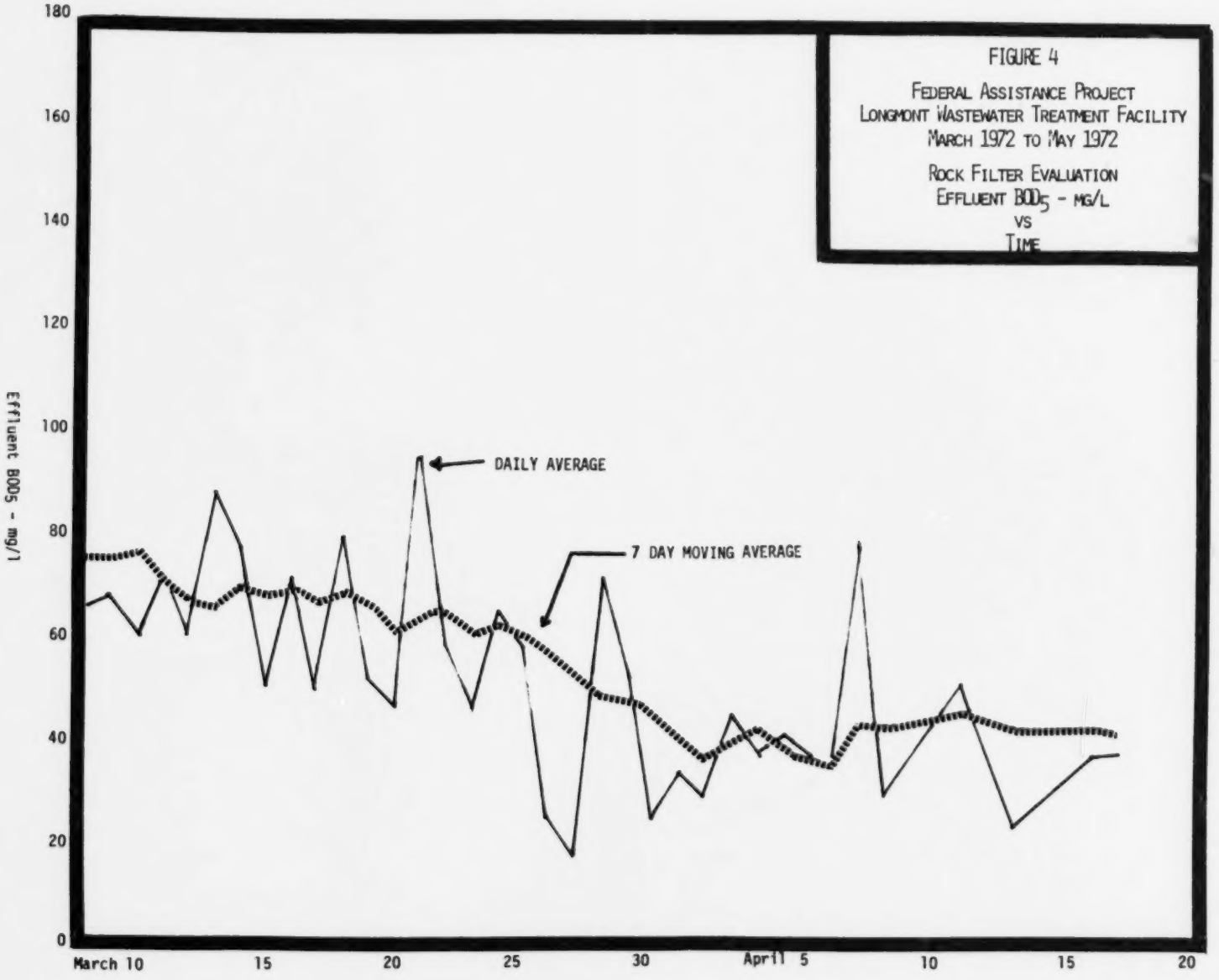
FIGURE 4
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
ROCK FILTER EVALUATION
EFFLUENT BOD5 - MG/L
VS
TIME
Effluent BOD5 - mg/l
180
160
140
120
100
80
60
40
20
0
DAILY AVERAGE
7 DAY MOVING AVERAGE
March 10
15
20
25
30
April 5
10
15
20

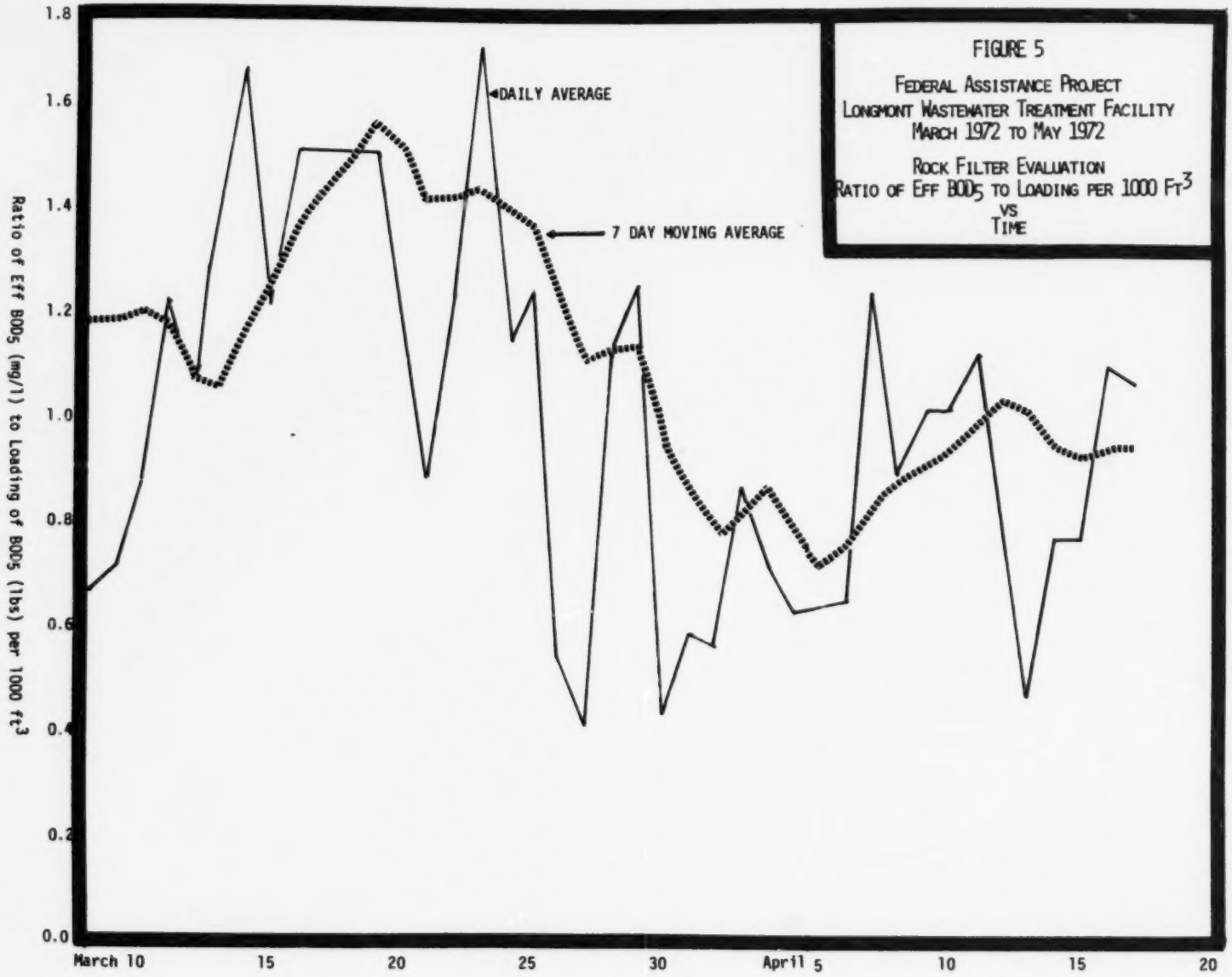
FIGURE 5
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
ROCK FILTER EVALUATION
RATIO OF EFF BOD5 TO LOADING PER 1000 FT3
VS
TIME
DAILY AVERAGE
7 DAY MOVING AVERAGE
Ratio of Eff BOD5 (mg/l) to Loading of BOD5 (lbs) per 1000 ft3
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
March 10
15
20
25
30
April 5
10
15
20

Figure 6 shows the loading applied to the redwood (ABF) filter in lbs. of BOD_5 per 1000 cubic feet. The graph shows that the seven day average load was well below the design value of 175 lbs. of BOD_5 per 1000 cubic feet. The seven day average load leveled out at around 110 lbs. of BOD_5 per 1000 cubic feet. The daily average loading exceeded the design load only once - on March 20, 1972. Despite the loadings lower than design and the increase in mixed liquor solids, the performance of the ABF unit did not improve dramatically. Figure 7 shows the effluent BOD_5 for the ABF side of the plant. The reduction of effluent BOD_5 is indicated by the seven day average from greater than 80 mg/l to a low of 60 mg/l and then an increase to 70 mg/l of BOD_5.

The effect of improved operational controls is more dramatically shown in Figure 8. Figure 8 is a plot of the ratio of effluent BOD_5 to loading per 1000 cubic feet versus time. A plot of this type helps to eliminate some of the effect of a fluctuating load on effluent BOD_5 and shows that improvement occurred despite the increasing load. However, the improved controls and control testing seemed to have an effect only to a certain level and then no further improvement is indicated.

In interpreting Figure 8, it appears that a ratio of 0.6 is the best that can be achieved at the Longmont plant. This would mean (assuming a straight line relationship) that in order to achieve an effluent BOD_5 concentration of 25 mg/l, the ABF tower would have to be loaded at no more than 40-45 lbs. of BOD_5 per 1000 cubic feet. This is far below the design loading of 175 lbs. per 1000 cubic feet.

Based on the above analysis, it appears that the ABF tower is not capable of producing a satisfactory effluent even with good, or at least improved, operational controls. Three things concerned with the design of the unit appear to be the limiting factors in improving the effluent from the ABF unit.

The final clarifier appears to be too large. Detention time in the final clarifier at a flow of 1.5 MGD (See Figure 2) is 6.5 hours with an overflow rate of 210 gallons per day per square foot. Although peak flows exceed these values, they do not approach commonly used design values (i. e., 2 hours detention or 800 gallons per day per square foot overflow rates). It is noted that design flow is 2.24 MGD, however 1.5 MGD was actual flow. The effect of the large clarifier is that it serves, simply by its sheer size in relation to the rest of the system, as a reservoir of the solids. The environment of the clarifier which is generally anaerobic, has an adverse effect on the aerobic bioligical organisms. Another feature of the final clarifier that may have affected performance is the scraper type sludge collector mechanism. This type is generally considered inferior to the suction type collector for removing aerobic organisms from a clarifier.

A method of eliminating some of the adverse effects on the aerobic solids from the ABF tower would be to decrease the quantity of sludge (organisms) going to the clarifier by increasing the amount of mixed liquor returned directly to the wet well. This points out the second item inhibiting improvement

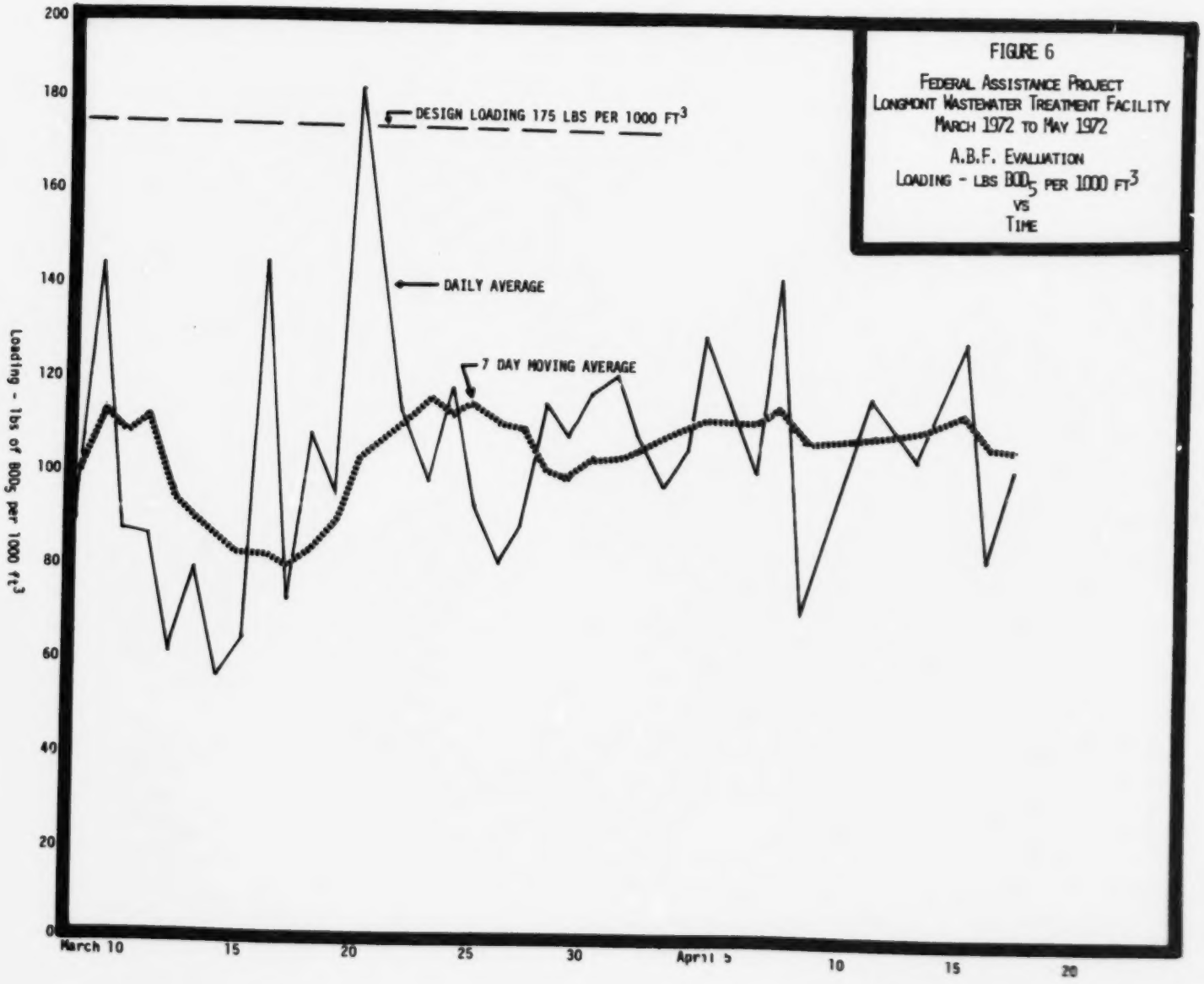

FIGURE 6

FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972

A.B.F. EVALUATION
LOADING - LBS BOD_5 PER 1000 FT^3
VS
TIME

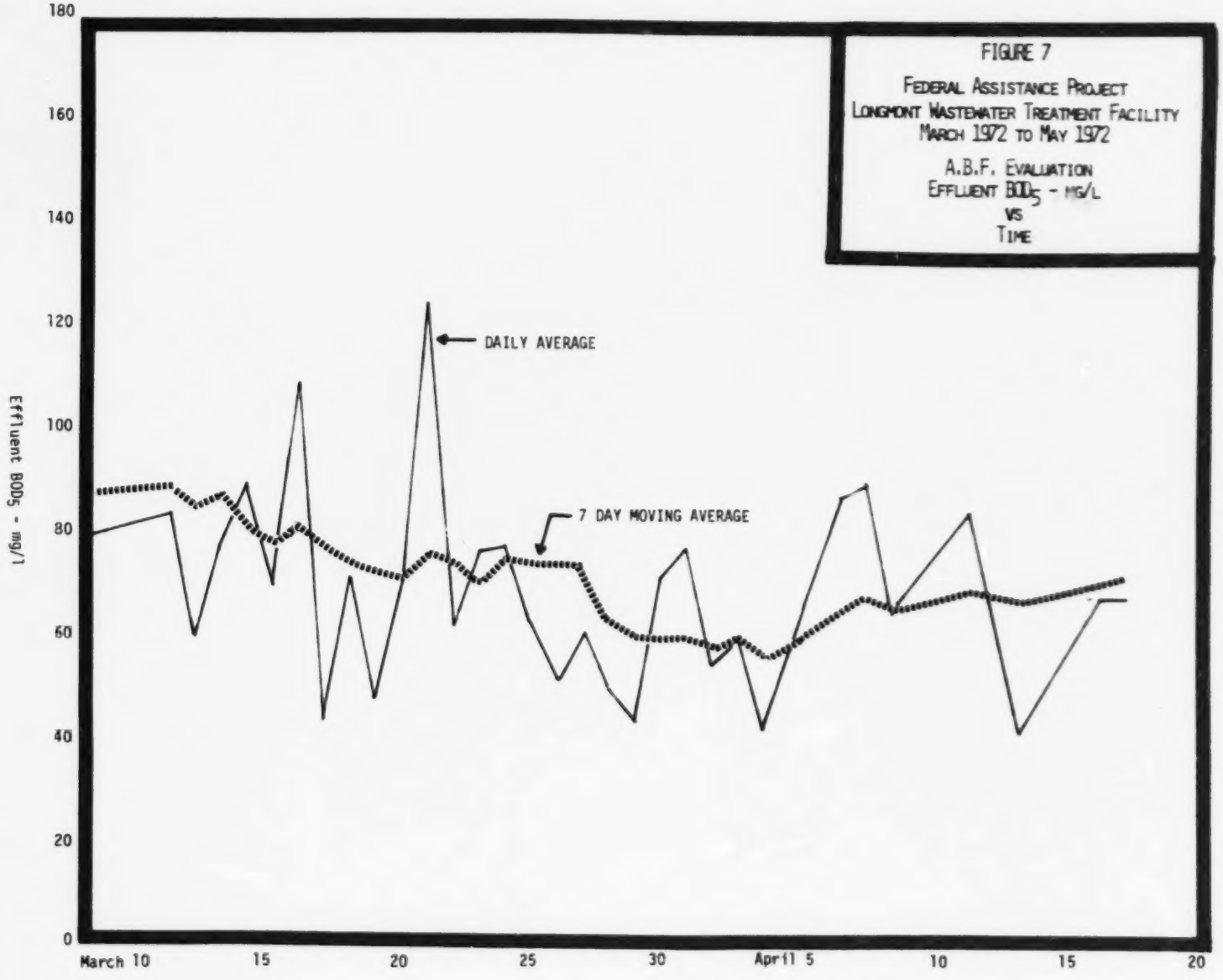
FIGURE 7
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
A.B.F. EVALUATION
EFFLUENT BOD_5 - MG/L
VS
TIME
DAILY AVERAGE
7 DAY MOVING AVERAGE
Effluent BOD5 - mg/l
180
160
140
120
100
80
60
40
20
0
March 10
15
20
25
30
April 5
10
15
20

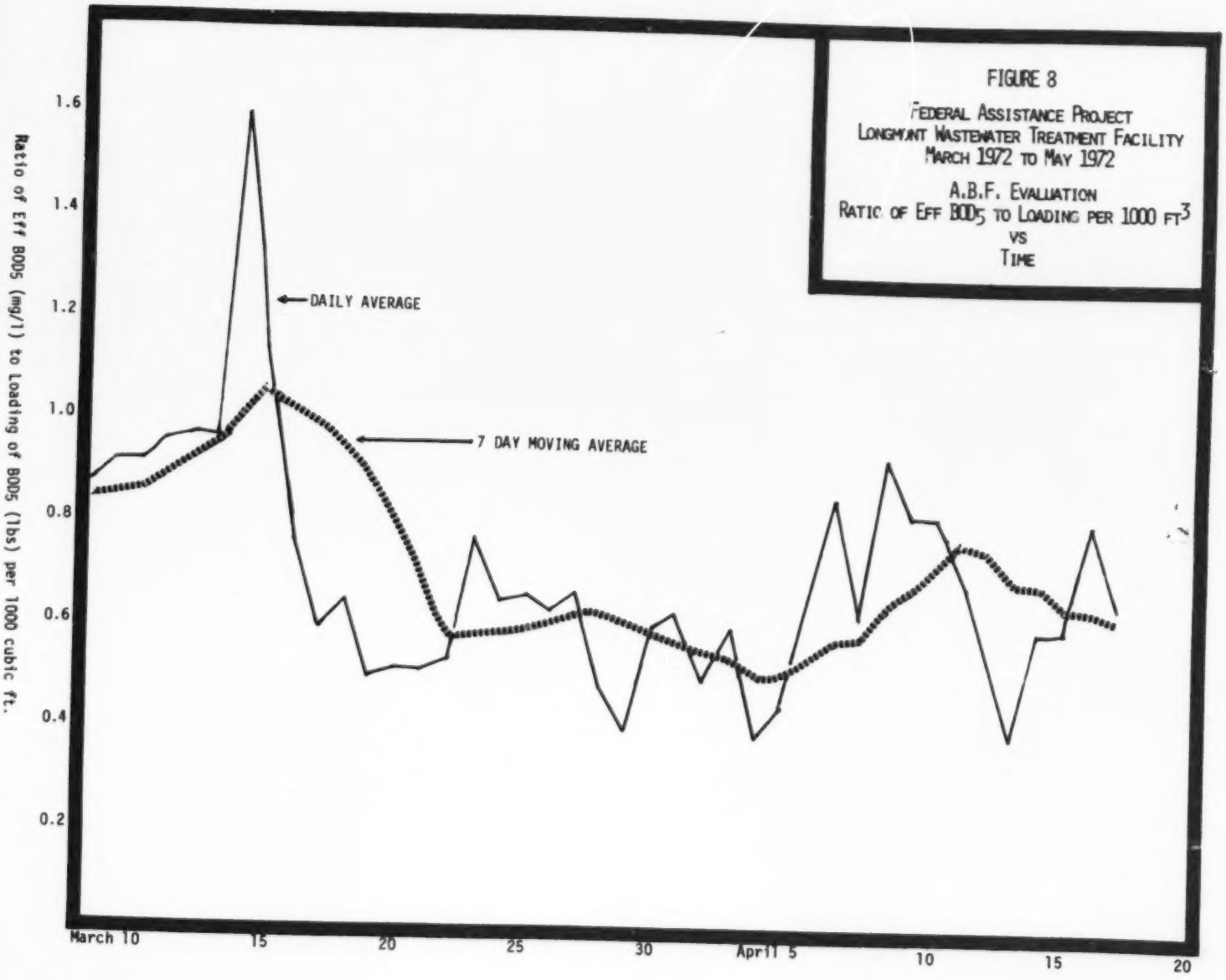
FIGURE 8
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
A.B.F. EVALUATION
RATIO OF EFF BOD5 TO LOADING PER 1000 FT3
VS
TIME
DAILY AVERAGE
7 DAY MOVING AVERAGE
Ratio of Eff BOD5 (mg/l) to Loading of BOD5 (lbs) per 1000 cubic ft.
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
March 10
15
20
25
30
April 5
10
15
20

of the ABF performance. The amount of flow or mixed liquor that can be returned to the wet well directly is limited by the 10 inch line presently in use at the plant. A variable flow control for returning a desired amount of mixed liquor appears to be necessary.

The third and most critical limiting factor at the Longmont Plant appears to be the depth and/or volume of the redwood media. The relatively shallow depth of the Longmont filter (i.e.,5 feet) does not allow for sufficient contact time to effectively remove the soluable BOD_5 from the sewage as it flows vertically through the tower. This problem is somewhat compounded by the turbulence caused by the rotary distributor, which literally knocks any growth off the top 6 inches of filter media and by the inactivity of the organisms that are returned from the final clarifier.

All of the above items are interrelated. However, it is doubtful if any significant improvement can be achieved without first approaching the problem of the contact time in the redwood filter.

The above analysis also leads to another conclusion. The redwood media that is available at Longmont to replace the rock in the old filter will not provide a satisfactory effluent since two of the same shortcomings outlined above would also affect the "old" filter. The depth of the redwood and the lack of flexible control on the volume of mixed liquor return would be inadequate to provide the treatment necessary to handle the waste.

Several other items that would aid in operation of the ABF unit are outlined below. Flow measuring devices on the return sludge line, the mixed liquor line and the waste sludge line would be very beneficial in determining and maintaining a desired solids distribution in the system. Besides the flow measuring devices, the ability to fluctuate the flow of each of the three streams outlined above would be desirable. For example, a variable speed pump for the return sludge would greatly extend operational flexibility. Another desirable feature would be to install a smaller and independent waste sludge pump in the ABF system. This would allow more frequent wasting of lesser amounts which would be more desirable than the current "slug" wasting methods that are required by the present equipment.

3. Analysis of Other Plant Units

In addition to the two filters, several other portions of the plant were investigated to evaluate operational practices.

The digestors had not been in operation on a daily basis for several months prior to the assistance project. The plant superintendant had been "feeding" the digestors moderately in an attempt to develop active gas-producing digestors. This goal had been accomplished. Both the primary and secondary digestors were very actively producing gas and all parameters (pH, alkalinity and volatile acids) appeared to be satisfactory. However, major difficulties and numerous plant upsets occurred during the assistance project when the operators attempted to draw supernatant from the secondary digestor back to the head of the plant. The reason for the upset was the fact that digestion was not being completed in the primary gas mixed digestor and active decomposition and gas production was taking place in the secondary digestor. Although

the secondary digestor is unmixed, the mixing caused by digestion was adequate to prevent any development of a supernatant layer. Testing of the various draw-off ports on the secondary digestor showed an almost equal solids distribution throughout the tank. Therefore, the so-called supernatant that was being returned to the head of the plant was actually partially digested sludge with a solids concentration of 20,000 to 30,000 mg/l. It is recommended that, until the secondary digestor is capable of developing a supernatant layer, the digested sludge from the secondary be drawn to the sludge drying beds and/or centrifuged and hauled to a landfill. It would also be beneficial to use the secondary digestor as a primary digestor to increase the plant's digestion capacity. Plant personnel reported they have not had good results in the past trying to centrifuge digested sludge. It may be necessary to add polymers to obtain satisfactory results with the centrifuge. In any event, "supernatant" as it presently exists at Longmont must not be returned to the head of the plant. Instead, sludge should be centrifuged and the centrate be returned to the thickener or the sludge should be drawn to the drying beds. In the event that a "good" supernatant layer can be developed in the secondary digestor, it should be possible to begin returning supernatant to the head of the plant.

At Longmont, a thin sludge is drawn from the primary clarifiers, then is passed through a cyclone grit separator and then to a sludge thickener. Raw sludge from the thickener normally would go to the digestor. However, a portion of the time, raw sludge has been centrifuged. It appears that the centrifuge has the effect of making soluable a portion of the BOD_5 attached to the sludge solids. This increases the load to the secondary portion of the plant and therefore, centrifuging of raw sludge should be avoided if at all possible. Grit removal prior to the primary clarifier and pumping of primary sludge directly to the digestors might also effectively remove BOD_5 that is presently "washed off" solids, using the present sludge handling facilities. No studies were conducted to support this aspect of operation and, therefore, the operators should develop a testing program to analyze the sludge handling facilities of the plant in the near future.

4. Analysis of Total Plant Performance

Effluent quality at the Longmont waste water treatment facility is depicted in Figure 9. The seven day moving average indicates a reduction of BOD_5 from 70 mg/l to values between 50 to 60 mg/l. The majority of this decrease can be attributed to the decreased loading to the rock filter and to the improved operational control of the ABF tower. The fluctuations that are indicated in the effluent BOD_5 at Longmont after assistance began can be attributed to numerous factors, including: a change in plant personnel, clogging of the sludge thickener draw-off line, drawing a very poor quality "supernatant" back to the head of the plant, the effects of centrifuging raw sludge, etc. Many of these difficulties can be expected in the routine operation at most plants and some variation in the effluent quality is expected. However, the significant point is that, despite the improvement after assistance, the effluent, even at best, was not of a satisfactory quality (i.e.,seven day average was never less than 45 mg/l).

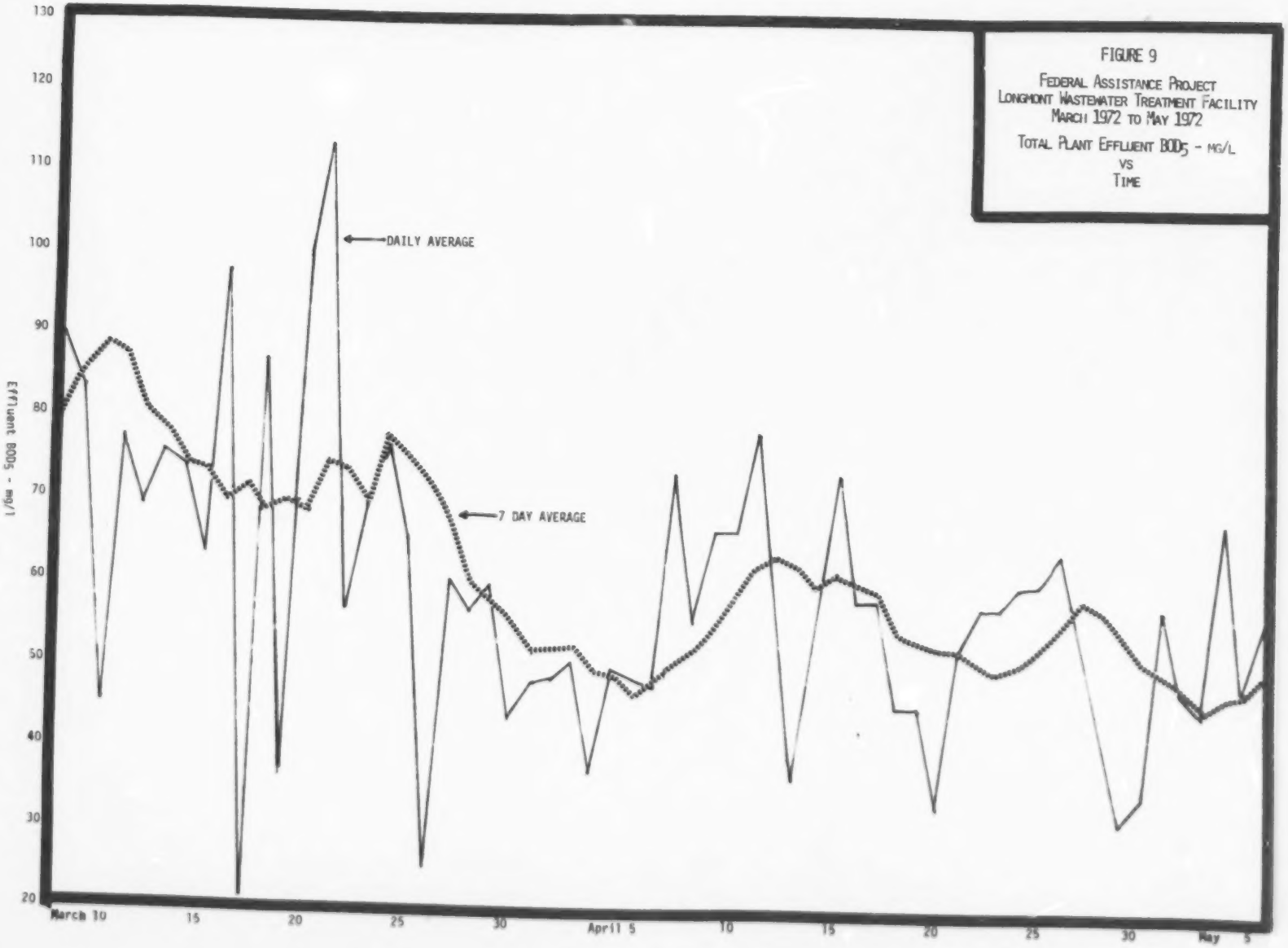
FIGURE 9
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
TOTAL PLANT EFFLUENT BOD5 - MG/L
VS
TIME
DAILY AVERAGE
7 DAY AVERAGE
Effluent BOD5 - mg/l
130
120
110
100
90
80
70
60
50
40
30
20
March 10
15
20
25
30
April 5
10
15
20
25
30
May 5

Figure 10 graphically depicts the total plant performance at Longmont as measured by the percentage reduction of BOD_5. A gradual increase in removal is indicated to a seven day average high of 77 percent, which was achieved on April 2, 1972. However, after that peak and a rapid decline in percent reduction, which was due to some of the problems outlined above, the plant seems to have leveled off at about 70 percent reduction of BOD_5. This is below the required state water quality standard of 80 percent reduction of BOD_5. It is noted that some values on a daily basis show an 80 percent reduction. However, this is not a consistent occurrence and it appears that 80 percent reduction is a borderline value to be obtained rather than a minimum value that the plant should achieve. It definitely appears that despite the improvements shown by the technical assistance and despite the feasibility of improved performance with the improvement of existing operational practices that the Longmont plant will not be able to consistently achieve a minimum of 80 percent removal of BOD_5 without major plant modifications.

V. SUMMARY AND CONCLUSIONS

Since the treatment plant at Longmont, Colorado, was not providing a satisfactory effluent, an operational assistance project was initiated in an effort to improve the effluent quality. The concentration of BOD_5 in the effluent was measurably reduced due to operational changes and control. The effluent was reduced from a concentration of 70 mg/l to 50 to 55 mg/l BOD_5. However, this effluent concentration is not a satisfactory quality. Various plant facilities appeared to be the factors limiting the production of a satisfactory plant effluent. It was concluded that the main limiting factors on the ABF unit were the lack of sufficient contact time (i.e., depth) of the redwood media, the lack of variable return mixed liquor flow and the large final clarifier. Other factors limiting operational capability were the lack of flow meters, the lack of variable flow control and the lack of a separate sludge wasting system. Since similar design features that exist in the ABF filter and apparently inhibit performance would be incorporated in replacing the existing rock filter with redwood media, it is concluded that replacement of the existing rock would not give the desired results.

Despite the improvements in effluent quality shown by the technical assistance project, and despite the feasibility of improved performance with continued improvement in operational controls and adjustments, the Longmont plant will not be able to provide a high quality effluent and probably will not be able to consistently provide a BOD_5 reduction of 80 percent. Major plant modifications appear to be necessary to provide an effluent of satisfactory quality.

Control testing that was initiated during the assistance project proved to be satisfactory to control the plant's performance. The daily testing and data interpretation should be continued.

"Supernatant" should not be returned to the head of the plant until such time that a true supernatant layer can be developed in the secondary digestor. In the meantime, both digestors could be used as primary digestors with the sludge being drawn off to the drying beds or the centrifuge and return the centrate to the sludge thickener. Flocculating agents may be needed to aid in the centrifuging of digested sludge.

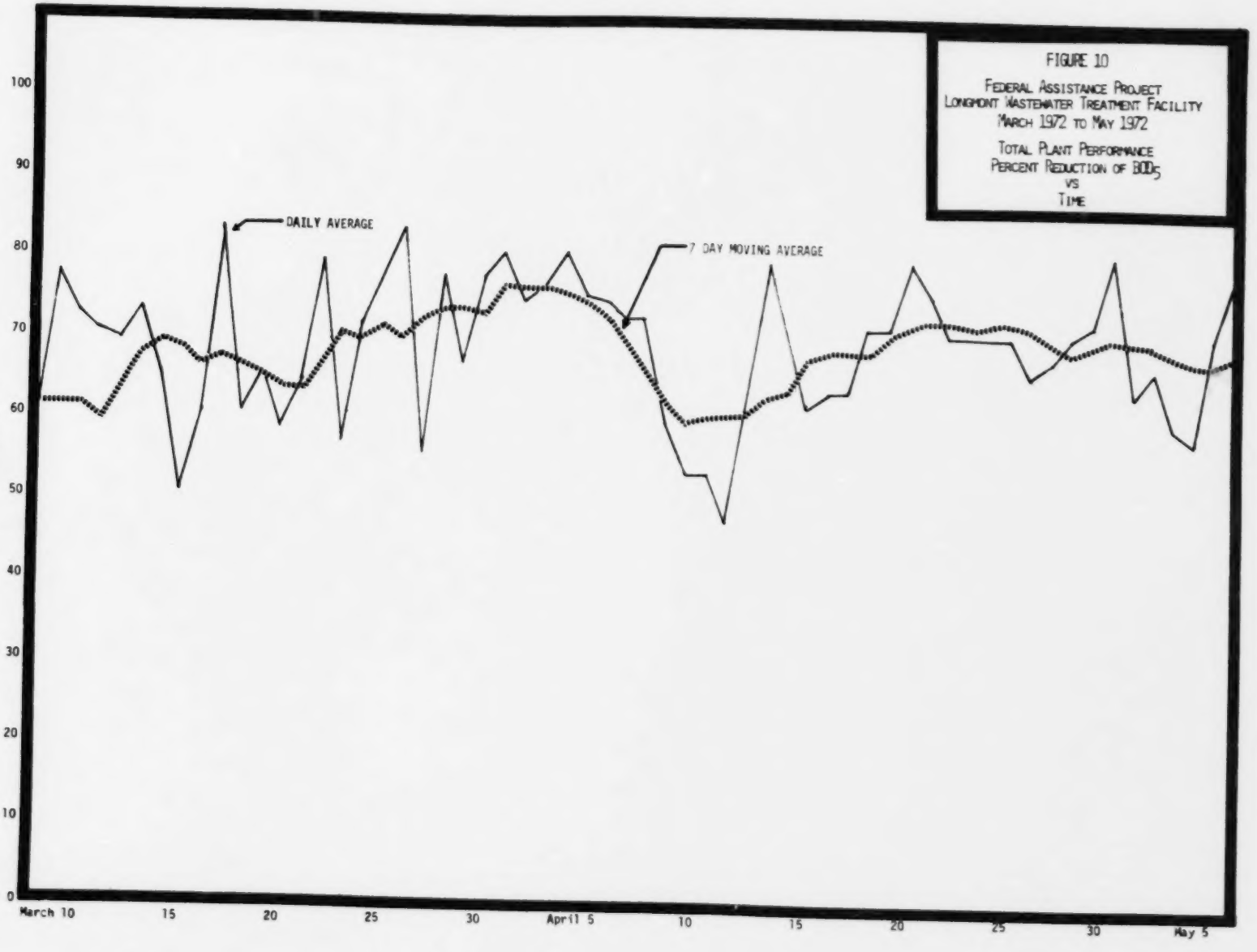
FIGURE 10
FEDERAL ASSISTANCE PROJECT
LONGMONT WASTEWATER TREATMENT FACILITY
MARCH 1972 TO MAY 1972
TOTAL PLANT PERFORMANCE
PERCENT REDUCTION OF BOD_5
VS
TIME
DAILY AVERAGE
7 DAY MOVING AVERAGE
Per Cent Reduction of BOD_5 - %
100
90
80
70
60
50
40
30
20
10
0
March 10
15
20
25
30
April 5
10
15
20
25
30
May 5

Raw sludge should not be centrifuged since it appears to cause an increased organic load on the secondary portion of the Longmont plant.

The sludge thickener operation and function should be evaluated and an attempt should be made to compare the present sludge handling system with one where grit removal is accomplished prior to primary settling and the sludge is drawn directly from the primary clarifiers to the digestors. It is felt that a system of this type may provide better BOD_5 reductions than the present system. However, data is needed to evaluate this conclusion.

The laboratory assistance program was initiated to evaluate the methods of analysis used in the Longmont Laboratory. Precise and reliable analytical results from this laboratory were achieved by instituting appropriate changes in laboratory techniques and by the purchasing of a few items of laboratory equipment. These changes should remain a part of the routine laboratory operation and every effort should be given to monitoring precision by performing duplicate analysis on 10-20% of the samples.

VI. RECOMMENDATIONS

The following recommendations are made:

A. Testing and data analysis initiated to control the operation of the ABF filter should be continued.

B. Laboratory techniques that were instituted should remain a part of the routine laboratory operation and effort should be given to monitoring precision by performing duplicate analysis on 10-20% of the samples.

C. The operational guidelines listed below should be followed:

1. Flow adjustments should be made between the two filters to determine the optimum flow distribution as measured by a minimum effluent BOD_5.

2. Raw sludge should not be centrifuged if at all possible.

3. "Supernatant" should not be returned to the head of the plant until such time that a supernatant layer can be developed in the secondary digestor.

4. Digested sludge should be centrifuged or drawn to the sludge drying beds. It may be necessary to use a flocculating agent or agents to aid in centrifuging digested sludge.

5. Analysis of all plant functions should continue in an effort to "fine tune" the performance of the facility.

D. The plant must be modified to provide an effluent of high quality. Although specific recommendations are not given as to the type of modifications, the following suggestions are made:

1. The ABF side of the plant will require a redwood tower with greater contact time (i.e. depth).

2. Flow capacity to the ABF side should be increased to overcome some of the difficulties presented by the large final clarifier and its associated detention time.

3. Increase flexibility of control, such as variable mixed liquor return, variable return sludge pumping, separate sludge wasting and flow measuring devices should be considered and preferably incorporated in modifications to the ABF tower.

4. An evaluation of grit removal prior to primary settling and direct pumping of sludge from the primary clarifiers should be made in comparison with the existing system.

5. The rock in the old filter should not be replaced with the available redwood media. If the redwood is used, a new tower or filter should be constructed more in line with the design requirements of the ABF process.

6. Since major modifications appear to be required, other available processes should be considered in the expansion.